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Field Survival and Growth of Douglas-fir by Age and Size of Nursery Stock

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Contents

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Reference Abstract

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Douglas-fir transplant stock survived better and grew more during the fourth season after planting than seedling stock from the same seed source when planted in clearcuts in the Oregon Cascade Range.

KEYWORDS: Growth (outplant) -)stock size, nursery transplants, seedling survival, Douglas-fir, *Pseudotsuga menziesii*.

RESEARCH SUMMARY

Research Paper PNW-217

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Seedlings and transplants from two Douglas-fir seed sources were planted near Oakridge, Oregon, in both fall and spring of 2 successive years to study field survival and growth in relation to nursery stock age and size. Height, diameter, and ovendry weight were the stock variables measured. Seedling size increased from 1+0 through 3+0. Both transplant classes averaged slightly shorter and heavier than 2+0 stock; 2+1's were slightly taller and heavier than 1+1's; 3+0 stock was tallest and heaviest. In general, transplants performed significantly better than seedlings. Other comparisons were also statistically significant but real differences were small. Actual survival and growth did not differ enough to warrant a recommendation of transplants over seedlings. Ranking of survival and growth during the fourth growing season for the 3,000-foot (914-m) and 3,500-foot (1 067-m) seed sources was:

Rank	Survival				Growth			
	3,000 feet		3,500 feet		3,000 feet		3,500 feet	
	Age class	Percent	Age class	Percent	Age class	cm	Age class	cm
1	1+1	76	2+1	56	1+1	27.1	1+1	23.2
2	2+1	68	1+1	54	2+1	26.4	2+1	22.6
3	3+0	65	3+0	49	3+0	25.3	1+0	20.0
4	2+0	64	2+0	47	1+0	25.2	3+0	19.9
5	1+0	55	1+0	32	2+0	23.4	2+0	19.3

The study was conducted on moderate to steep, relatively clean, south slopes judged by local foresters to be difficult sites. Results should apply on the west slopes of the Cascade Range in all areas with regeneration problems similar to those on the Oakridge Ranger District.

Introduction

This paper reports results of a study of field survival and growth of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) seedlings and transplants produced at Wind River Nursery near Carson, Washington, and transplants grown at the Westfir Transplant Nursery near Oakridge, Oregon. Stock was planted on the Oakridge Ranger District, Willamette National Forest, on sites chosen for their reforestation difficulty. Most units were on south- or southwest-facing slopes though three were nearly flat. Most had been burned 1 or 2 years before the planting and were clear of logging debris and vegetation. Two units were heavily vegetated; one contained much logging debris.

Study Design and Installation

Seed sources from the McKenzie and Lowell Ranger Districts of the Willamette National Forest from 914-meter (3,000-foot) and 1 067-meter (3,500-foot) elevation, respectively, were used at appropriate elevations. Seedlings of seven age-class lots were planted: 1+0, 2+0, and 3+0 from Wind River Nursery and 1+1 and 2+1 from Wind River and from the Westfir Transplant Nursery. The study required 12 clearcut units, 3 for each seed source in each of 2 successive years of installation. Trees were planted in blocks containing 14 rows of 25 trees each--1 row randomly assigned to each of the seven age-class lots planted in the fall and again in the spring. Blocks were replicated three times in each unit; spacing was 2.4 by 2.4 meters (8 by 8 feet), rows were oriented down the slopes. This arrangement was analyzed as a completely random split-plot design.

Trees were taken from nursery beds and graded by nursery personnel. All stock planted during a given season was lifted within 2 days and stored at Westfir in a refrigerated van until planted. All trees in a given block and season were planted by the same planter. As stock was packed for transport to the study area, two bags of 25 trees each from each age class lot were removed for tree measurements in the laboratory. Laboratory samples were collected during fall and spring of year 1 and fall of year 2. Collections were averaged together within age classes to characterize nursery stock. Nursery data were not analyzed statistically.

Data Collection

Nursery stock stem diameter 1 centimeter (0.39 in) below the cotyledonary node, stem height from the cotyledonary node to the tip of the terminal bud, and ovendry top and root weight after drying to constant weight at 80 °C (176 °F) were measured in the laboratory. Survival percent, height growth, and total height were recorded at the end of each of four growing seasons. Only 4th-year data are reported here.

Results and Discussion

NURSERY STOCK

For source 3,000 (McKenzie Ranger District), 3+0 seedlings were taller, larger in diameter, and heavier than 2+0 and 1+0 seedlings. Transplants were shorter than 2+0 seedlings, 2+1's shorter than 1+1's (table 1). Stock of source 3,500 (Lowell Ranger District) was similar but 1+1's were larger than 2+0's and 2+1's larger than 1+1's. Frost has always been a problem at Wind River Nursery and may have influenced seedling sizes, differentially between sources, since source 3,500 could be expected to be more frost resistant than source 3,000. Frost occurrence probably did not adversely affect field growth of individual trees.[1]

[1] Edgren, James W. 1970. Growth of frost-damaged Douglas-fir seedlings. USDA For. Serv. Res. Note PNW-121, 8 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Table 1--*Average nursery stock characteristics of five age class lots for Douglas-fir seedlings from two seed sources*[1]

Age class[2]	Source, 3,000 feet				Source, 3,500 feet			
	Height[3]	Diameter[4]	Dry weight	Top-root ratio	Height[3]	Diameter[4]	Dry weight	Top-root ratio
	cm	mm	g		cm	mm	g	
1+0	7.4	1.5	0.5	1.5	6.4	1.4	0.4	1.6
2+0	21.3	3.6	3.4	2.2	19.1	3.4	4.1	1.8
3+0	27.7	6.1	10.4	2.1	27.6	5.2	8.2	1.9
1+1	16.8	4.4	4.5	1.6	19.7	4.6	5.2	1.7
2+1	15.9	5.0	6.2	1.3	20.9	5.3	8.4	1.4

1/ Basis is 150 trees per age class per source.

2/ 1+0, 2+0, and 3+0 were from Wind River Nursery; 1+1 and 2+1 were from Wind River Nursery and from Westfir Transplant Nursery.

3/ For inches, multiply by 0.3937.

4/ For inches, multiply by .03937.

Dry weight top-root ratios (T/R) of 2+0 and 3+0 were highest for each source; ratios of 2+1's were lowest. Two-year-old transplants (1+1) had intermediate ratios. First-year seedlings (1+0) had ratios most nearly like 1+1's (table 1).

FIELD SURVIVAL

Survival differences among age classes, though statistically significant were too small to influence management decisions (table 2). No differences were large enough to justify recommendation for or against a specific nursery or age class except for 1+0; use of 1+0 would not be wise. Other survival differences revealed here can readily be compensated for by planting a few extra trees per acre. However, it is of academic interest that transplants survived better than seedlings (see appendix).

Fall-planted stock survived best in the 1st planting year and spring-planted stock survived best the 2d year; the difference was significant (table 3). Again, no recommendation can be made as the difference was clearly attributable to weather conditions. After spring planting the 1st year, the weather turned warm and dry and remained so until mid-September. Trees planted during the first fall, 6 months earlier, probably were better established going into the dry summer. Weather during the second summer was unusually cool and wet and seedlings planted that spring benefited. Low survival of source 3,500 planted during year 1 can be attributed to vegetative competition.

FIELD GROWTH

Like survival differences, some growth differences were statistically significant but not large enough to influence management decisions (table 2). Transplants of source 3,000 grew significantly better than seedlings; those from Westfir outperformed those from Wind River. No significant growth differences occurred among age classes of source 3,500, probably because stock planted during the 2d year was extensively damaged by deer browsing in two of three units planted that year.

Table 2--*Average survival, height growth, and total height of Douglas-fir trees after 4 years in the field, by nursery age class and seed source*

Age class[1/]	Source, 3,000 feet			Source, 3,500 feet		
	Survival	Growth[2/]	Total height[2/]	Survival	Growth[2/]	Total height[2/]
	Percent	- - - - cm - - - -		Percent	- - - - cm - - - -	
1+0	55	25.2	65.9	32	20.0	56.2
2+0	64	23.4	67.4	47	19.3	62.5
3+0	65	25.3	80.4	49	19.9	65.9
1+1	76	27.1	77.8	54	23.2	75.7
2+1	68	26.4	72.7	56	22.6	71.9

1/ 1+0, 2+0, and 3+0 were from Wind River Nursery; 1+1 and 2+1 were from Wind River Nursery and from Westfir Transplant Nursery.

2/ For inches, multiply by 0.3937.

Table 3--*Survival and growth of seedlings from two Douglas-fir seed sources planted in fall and spring of 2 successive years*

Year	Season	Source, 3,000 feet		Source, 3,500 feet	
		Survival	Growth	Survival	Growth
		Percent	cm	Percent	cm
1	Fall	66.4	24.8	35.9	22.5
1	Spring	57.5	24.1	17.5	19.8
2	Fall	68.3	27.6	68.0	21.4
2	Spring	78.3	26.8	78.4	22.1
Statistical significance		**	N.S.	**	N.S.

** = significant at 99-percent level.
N.S. = not significant.

TOTAL HEIGHT OF PLANTED STOCK

Tallest nursery stock did not grow best. For source 3,000, 3+0 stock averaged 10.9 cm (4.3 in) taller than 1+1 stock (table 1). After 4 years, trees from 3+0 stock were only 2.6 cm (1.0 in) taller than 1+1's, an 8.3-cm (3.3-in) gain for 1+1 stock (table 2). For source 3,500, the differences are more striking. Though 3+0 stock averaged 7.9 cm (3.1 in) taller than 1+1 stock at the nursery, trees from 1+1's averaged 9.8 cm (3.8 in) taller than those from 3+0's--a 17.7-cm (7.0-in) gain for 1+1's after 4 years of growth. Similar comparisons can be made of 1+1's with 2+1's and also with 2+0's.

TOP-ROOT RATIO

As a measure of seedling quality, T/R (top-root ratio) by itself appears

to have limited application. Exclusive of 1+0's, stock with intermediate T/R's--1+1 transplants--performed best for both sources. Stock with either higher (2+0 and 3+0) or lower (2+1) ratios did not do as well. First-year seedlings (1+0), with T/R nearly the same as 1+1 in each source, performed poorest of all age classes in survival and about the same as 3+0 in growth. Clearly, it is impossible to generalize from these data about the influence of T/R on field growth and survival.

Conclusions

WHICH AGE CLASS TO USE?

These data strongly suggest that:

1. Two-year-old Douglas-fir seedlings are adequate for most moderate to steep, clean, south slopes (a) on the west slopes of the Oregon Cascade Range north of Crater Lake, (b) on other areas easier to reforest within this locality, and (c) in other localities of Oregon and Washington where reforestation problems are similar to those experienced on difficult planting sites of the Oakridge Ranger District.

2. Two-year-old Douglas-fir transplants, although superior to other stock in a statistical sense, did not perform well enough to warrant a recommendation.

3. Use of 3+0 or 2+1 stock is not justified because of their greater expense, unimpressive performance relative to 2+0, and the 1-year additional lead time required to produce it.

4. Tallest nursery stock did not perform best.

5. Top-root ratio was not a good estimator of seedling quality.

Acknowledgment

I wish to thank personnel of the Oakridge Ranger District and Supervisor's Office, Willamette National Forest, and the Wind River Nursery, Gifford Pinchot National Forest. Their help made this study possible.

Appendix

IMPLICATIONS FOR FUTURE RESEARCH

Though transplants did not perform well enough in this study to warrant a recommendation for their use, their statistically significant edge over seedlings cannot be ignored. These data suggest that the act of transplanting was primarily responsible for this edge. I suggest we must learn to produce a seedling with physical and physiological characteristics of a transplant. Three things occur in transplanting that seedling nursery stock does not experience. We must accomplish these by improved cultural practices in original seed beds, avoiding the added expense of transplanting.

First, the plants are disturbed during lifting and planting. This disturbance has long been recognized as beneficial.[2/] For many years, standard nursery practice has been to undercut seedlings early in spring to simulate the disturbance caused by transplanting. However, the single undercutting has questionable value.[3/] A promising technique called wrenching[4/] has been developed in New Zealand for Monterey pine (*Pinus radiata* D. Don) and has also been used there on Douglas-fir. The technique uses repeated passes of a cutting blade under seedlings in the nursery bed at intervals of 2 to 4 weeks to stop top growth and stimulate a fibrous root system. We must examine wrenching in efforts to produce transplantlike seedlings.

Second, uniform bed density must be considered in any effort to produce improved, transplantlike seedlings. At the time seedlings used in this study were grown, the density target was 40 seedlings or more per square foot. Transplants are grown at 8 to 10 or fewer per square foot. Current nursery studies[5/] suggest that a good bed density from a field standpoint may be no more than 20 seedlings per square foot. Possibly a good compromise between field performance and nursery economics will be between 20 and 30 2+0 Douglas-fir seedlings per square foot, near the density range recommended for efficient wrenching. Lower densities and uniform distribution hold promise for improved field performance. Less space is required for low density seedlings than for transplants; and uniform spacing reduces unequal competition and seedling size variability, thereby reducing culls and permitting efficient use of valuable seed.

Third, transplants may have been better performers than seedlings because they were subjected to more intensive grading and consequently more selective culling than seedlings--before transplanting, during growth after transplanting, and again before outplanting. Many seedlings that would have died when outplanted were thus weeded out by the transplanting process. Therefore, the transplanted stock was of higher quality. This culling function, achieved as a fringe benefit of transplanting, may not be as important for seedlings grown at realistic uniform bed densities.

[2/] Foster, C. H. 1932. Improvements in planting stock production. J. For. 30:797-799.

[3/] Edgren, James W. Field performance of undercut coastal and Rocky Mountain Douglas-fir 2+0 seedlings. (In preparation for publication, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.)

[4/] Rook, D. A. 1971. Effect of undercutting and wrenching on growth of *Pinus radiata* D. Don seedlings. J. Appl. Ecol. 8:477-490.

[5/] Edgren, James W. 1975. Douglas-fir 2+0 nursery stock size and first-year field performance in relation to seedbed density. Paper presented to Service-wide Planting Stock Conference, Coeur d'Alene, Idaho.

Demand for planting stock is increasing each year because more acres are planted with more trees per acre. Though lower seed bed densities may increase the number of nursery acres needed, nursery acres are more easily increased than seed supplies because good seed years do not occur frequently and regularly. Seed supplies could become the limiting factor in reforestation of some sites if we do not use seed efficiently. Overdense seed beds constitute inefficient use of seed. Fewer culls, resulting from lowered seed bed densities, also permit the production of more acceptable seedlings from a given number of acres.

In summary, future research on Douglas-fir nursery stock should concentrate on seed bed density and wrenching, with the goal of producing a 2-year-old seedling that performs like a transplant in the field. The 2-year period is desirable for at least three reasons: (1) a 3d year in this study did not help either seedlings or transplants, and either category grown at the proper density for normal 3-year growth would likely become too large for efficient handling and planting; (2) a 3-year nursery period requires foresters to order stock too far in advance for efficient planning; and (3) 2-year-old seedlings experience less setback from lifting and planting than older seedlings.

Future research on seedling performance must include nursery cultural practices and physical measurements and must test across a range of site conditions likely to be encountered naturally or created artificially in the area for which the seedling is intended. We must not lose sight of the fact that reforestation constitutes a closed system. Manipulation of any of its components influences what happens in the other components.

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